Third United Nations International Conference on the Peaceful Uses of Atomic Energy

A/CONF.28/A/16
CANADA
February 1964
Original: ENGLISH

Confidential until official release during Conference

Abstract

THERMAL AND IRRADIATION PERFORMANCE OF EXPERIMENTAL FUELS OPERATING IN STEAM-WATER MIXTURES

A.D. Lane and J.G. Collier,
Chalk River Nuclear Laboratories,
Atomic Energy of Canada Limited, Chalk River, Ontario

1. Steam-water mixtures (fog) are capable of transporting large quantities of heat from a reactor; yet they do not demand excessive pumping power and do not introduce bulk quantities of neutron-absorbing material into the reactor core. Before fog is used in power reactors, more understanding must be obtained by research and development in three areas:

- thermal and hydrodynamic properties of fog systems
- fuel-sheathing materials suitable for use in fog
- chemistry of fog systems to minimize corrosion and deposition.

2. Electrically heated elements were used to simulate fuel in laboratory experiments carried out to

- measure "dry-out" heat fluxes for fuel strings ("dry-out" is the heat flux at which the film of water disappears from the heat-transfer surface and the heat-transfer coefficient suddenly falls)
- determine heat-transfer coefficients at heat fluxes beyond dry-out
- determine the effect of having elements of different lengths and having sections heated and unheated.

3. Five irradiations of fog-cooled fuel have been carried out in a loop in the NRX reactor. In the first irradiation the onset of dry-out was measured and it was shown that surface thermocouples could indicate incipient dry-out.

4. The second irradiation was run for 75 days, and provided data on the corrosion and hydrogen pick-up of fully wetted fuel sheaths fabricated from two different zirconium-base alloys.

5. The next three irradiations were undertaken to determine the corrosion and hydriding rates of zirconium alloys when operating beyond

dry-out at heat fluxes of 60, 70 and 90 W/cm^2. The time-to-failure at the highest of these heat fluxes was determined to be approximately 30 h. This compares reasonably well with predictions obtained from out-reactor corrosion rates with an allowance for the insulation of the corrosion film. The formation of defects was found to be gradual and did not result in catastrophic failures. Sheath temperatures up to 670° C were encountered for extended periods during these tests. In each of the three irradiations in this group, some of the fuel elements in the string had dry surfaces and the remainder had wetted surfaces. The transition from wet to dry surfaces was assisted by disrupting the flow of the water film with a surface discontinuity. The tests indicated a possible problem from thermal distortion of a fuel element when only part of its sheath is dry; this can accelerate the time to failure.

6. The irradiation tests have covered a range from 27 to 63 wt% steam at the outlet, and mass velocities from 107 to 136 g cm^{-2} s^{-1}; all the tests were conducted at a system pressure of 70 kgf/cm^2. In general, the dry-out results obtained from the irradiation experiments and the laboratory tests agree well with one another, and with those predicted from calculations of the flow of liquid films on heat-transfer surfaces.